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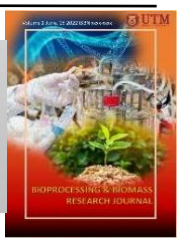

Research Article

# Formulation of Biscuits Containing *Eucheuma Cottonii* Powder and Physicochemical Properties Analysis of the Biscuits

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**ABSTRACT**

Food is now consumed not simply to satisfy hunger but also to meet nutritional demands and to reduce the risk of disease. People are starting to read and pay attention to the ingredients list on every food product they buy and eat. In response to public demand, a variety of food products that compromise health and diet benefits other than basic nourishment have been developed. Until now, very little research has been done on the substitution of wheat flour with *Eucheuma cottonii* (*E. cottonii*) powder in production of biscuits or cookies. Therefore, the present study aimed to develop biscuits formulation containing seaweed powder to produce seaweed biscuits and analyse the impacts of *E. cottonii* powder on the physicochemical quality of biscuits for instance physical characteristics, sensory properties, proximate analysis, and texture profile. Formulation of seaweed biscuits were using the same material as homemade biscuits. However, additional of *E. cottonii* seaweed powder at different ratio and amount of the ingredients were varied. Modification of biscuits formulation by added seaweeds powder give major influences on the physicochemical properties. Increased the percentage of seaweed powder had increased the level of hardness of biscuits and increased moisture content in seaweed biscuits. By adding seaweed powder in the formulation, it also influenced the appearance, aroma, taste, colour, texture, and sweetness of the biscuits.

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## INTRODUCTION

Presently, food eaten not only to fulfil hunger but also to cater nutritional needs and reduce the risk of disease. Now people start to read and put intention to the ingredients list in every food product that they bought and consumed. Respond to the people demand, various food product have been introduced to offer health and diet benefits beyond basic nutrition. Therefore, development of functional foods is instantaneously among the rapidly growing area of food product development globally. Functional foods with natural active ingredients are especially strongly preferred by people because of the safety concern. In this case, marine foods especially seaweeds are highly recommended to be commercial functional foods because it is richest source in nutrients, thus good for diet and health plus have its economic value for food industries.

Marine algae are divided into two main groups which are microalgae and macroalgae according to their physical sizes. Marine macroalgae are commonly known as seaweeds which can be divide broadly into three major classes based

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on their pigment containment. Red algae (*Rhodophyceae*) has a domain phycoerethrin and phycocyanin pigment and brown algae (*Phaeophyceae*) which has a dominant fucaxantin pigment (Leandro et al., 2020). The seaweed *Eucheuma cottonii* or now is known as *kappaphycus alvarezii* can be categorized as red algae because they are applied in the production of carrageenan and agar. According to Syamsuar (2007) stated that *Eucheuma cottonii* is one of type of red seaweed and changed its name to *Kappaphycus alvarezii* as carrageenan produced include kappa carrageenan fraction, thus taxonomically call *kappaphycus alvarezii. E. cottonii* has the highest growth rate among other *kappaphycus* seaweed which is beneficial for food and pharmaceutical applications (Patterson, Edward & Bhatt, 2012). In Malaysia *E. cottonii* is the most common type of red seaweed which has been cultivated largely in the farm around Sabah. In latest years, the production of *E. cottonii* has been demanded due to the interest in urban populations looking for natural and "health-promoting" foods (Phang et al., 2010).

According to Kumar et al. (2008) stated that *E. cottonii* has nutritional value that is higher than shark's fin, 10 times higher collagen than bird's nest, calcium is 600 higher than those found in animal's sources, iron content is 28 times the amount found in pork liver and pH 7.6 (neutral) suitable for the digestion process. *E. cottonii* is claimed to contain great source of micronutrient elements such as minerals and vitamins (Gupta & Abu-Ghannam, 2011), iodine (Zakaria et al,, 2018) and abundance resource of macronutrient components such as protein, carbohydrates, fiber, fat and amino acid (Dawczynski et al., 2007). In food industries E. cottonii is usually included into processed food products where it acts as stabilizer and texturing agent (Dellarosa et al., 2015).

The use of food additives in the baking industry has become a standard practice and is widely used. Hydrocolloids are becoming increasingly important in the baking industries in bread making, where their use improves the properties of the dough handling, enhances the consistency of fresh bread, enhances the nutrient content of final products and extends the shelf life (Arufe et al., 2018). Hydrocolloids can alter the heat properties and increase overall product quality (pasting and gelatinization) of starch. Additionally, Rosell et al. (2001) discover an enhancement in white dough stability during proofing process with adding of hydrocolloids, such as k-carrageenan and sodium alginate. Due to the thickening, emulsification, gelling and stabilization of alginate and salts, alginate and its salts are commonly applicated (Khotimchenko, 2001). According to Guard et al. (2004), alginates are anti-staling.

The meaning of hydrocolloids are all polysaccharides derived from sources of plants or algae and gums produced by chemical cellulose processes from plant exudates or modified biopolymers. The seaweed may be used in bakery production, according to Mamat et al. (2014). The attributes of high bakery products include a consistent crumb structure, high consistency, tenderness, shelf-life and stalking resistance. So, the condition of the final bakery product can be affected by the adding substances similar to hydrocolloids, which can influence these properties. The function of hydrocolloids in the food processing production is to helps in supplying dietary fiber or to affect the products' unique functional properties. These polysaccharides can delay retrogradation of starch, enhance food texture, improve moisture retention, and improve overall product quality during storage.

In this study, small percentage of *E. cottonii* powder could be used to substitute wheat flour while the end-product still preserving its quality compared to biscuits produced with no addition of *E. cottonii* powder. The addition of *E. cottonii* powder also influenced the dough and biscuits textural properties such as firmness, stickiness, color, and volume, showing a great impact on the dough and final product, respectively. By adding *E. cottonii* powder into food product formulation, it increased the level of hardness and moisture content in the seaweed biscuits.

## MATERIALS AND METHODS

### Seaweed Collection and Processing

Red seaweed (*E. cottonii*) samples were collected from Kota Kinabalu, Sabah during the month of October 2020. The seaweed (*E. cottonii*) was thoroughly washed and clean with fresh water to remove salt water and continues with deep soaking for overnight. After that, seaweeds were dried in tray dryers for 24 h at 40 $^{o}$C and then, the seaweed were stored in air–tight containers at room temperature. The dried seaweeds were ground into powder using a hand grinder. Then the seaweeds powder was sieved and stored in air-tight container at room temperature for further use.

### Biscuits Ingredients

150 g of wheat flour (brands Blue Key, 4% carbohydrate, 9% protein), 100 g of butter, (brands Buttercups, 83% fat and 1.4% protein) and 50 g of sugar, (Gula Prai, 100% carbohydrate).

### Formulation of Seaweed Biscuits

Three different formulation of seaweed biscuits combination from seaweed powder (10-20%) with wheat flour and one control sample of biscuit formulation were prepared as shown in **Table 1**.

**Table 1** The composition of seaweed (*E. Cottonii*) biscuits.

| Samples | A | B | C | Control |
|---|---|---|---|---|
| Wheat flour (g) | 135 | 127.5 | 120 | 150 |
| Butter (g) | 100 | 100 | 100 | 100 |
| Caster Sugar (g) | 50 | 50 | 50 | 50 |
| Seaweed Powder (g) (Percentage of seaweed (%)) | 15 (10%) | 22.5 (15%) | 30 (20%) | 0 (0%) |

### Preparation of Seaweed Biscuits

All the ingredients (wheat flour, seaweed powder, caster sugar and butter) were weighed according to **Table 1** using electronic balance. Dry ingredients such as wheat flour and seaweed powder were mixed with different ratios. Butter was softened and mixed with caster sugar and then mixed with dry ingredients. Each formulation of seaweed powder with wheat flour were added and stir together to make dough. Then, knead and rolled the dough with thickness of 8 mm. The pressed dough was cut into small round shapes and arranged on the trays. The biscuits were baked in air fryer (Khind ARF3000, Malaysia) at 165 $^{o}$C for 12 min.

**Texture Analysis**

The texture analysis was conducted using CT3 Texture Analyzer (Brookfield Ametex, USA). A compression test (texture profile analysis) was performed with 2 mm diameter stainless steel cylinder probe (TA39). The reading of hardness was repeated for six times for each of formulation to take the most accuracy reading.

**Determination of Height and Weight of Biscuits**

Height of biscuits before and after baked was measured to the nearest millimetre using micrometre while for weight of biscuits was measured by electronic balance of accuracy ±0.001 g.

**Color Analysis**

The color of seaweed biscuits was studied using colorimeter (Minolta CR 300, Japan) according to the CIE L* a* b* scale. The color reading included lightness (L*), redness (a*) and yellowness (b*). A standard white plate was used to calibrate the instrument with (X = 91.98, Y = 93.97, and Z = 110.41). Three sample of biscuits from each formulation was measured in triplicate to get accurate reading.

**Protein Analysis**

The protein analysis of 50 g of seaweed (*E. cottonii*) powder were analysed using the Association of Official Analytical Chemists (AOAC) method of AOAC 2001.11 in AOAC (1995).

**Moisture Content**

Moisture analysis was conducted by using a moisture analyzer (OHAUS Moisture Analyzer MB25, USA). Three sample of biscuits from each formulation were crushed to small particles using roller and measured using moisture analyzer to obtain the moisture content in %.

**Sensory Evaluation**

Sensory evaluation was carried out to evaluate the appearance, colour, aroma, texture/mouth feel, taste, and sweetness of the costumer towards the seaweed biscuits. The result has been recorded and analysed using Hedonic rating scale to determine the significant different between samples. This sensory evaluation was performed by 15 untrained panels from UTM staffs and students. The result was recorded and analysed from their review and comments. The assessment used a five-point hedonic scale from 1 to 5 (1=dislike very much, 2=dislike slightly, 3=neither like nor dislike, 4=like slightly, 5=like very much). Before presented to the panels for testing, all samples were kept in air-tight container at room temperature.

**Data Analysis**

All results were reported as means ± standard deviation (SDEV) for three replicates. The experiment was statistically analysed and performed using the Microsoft Excel. A difference of $P < 0.05$ level was considered as statistically significant. Besides, t-test was calculated to determine the statistically significant of the result obtained.

**RESULTS AND DISCUSSION**

**Texture Analysis**

**Table 2** showed the texture analysis result for different formulation of seaweed biscuits. The experimental texture analysis data displayed that the seaweed powder not significantly affected the texture characteristic of biscuits including hardness parameter ($P>0.05$). The trend level of hardness for seaweed biscuits shows increased significantly when the percentage of seaweed powder in biscuits were increased but a bit lower compared to control samples. The biscuit with 20% of seaweed powder (sample C) used the highest amount of force for compression. According to Jayasena and Nasar-Abbas (2011) the change of biscuits texture may be associated with the change in volume. By adding the seaweed powder to the biscuits increased their density and reduced the number of air pockets, thus increasing the force required for compression, which were related to a decrease in biscuits volume.

**Table 2** Texture analysis result for different formulation of seaweed biscuits.

| Sample | Level of Hardness (g) |
|---|---|
| Control | 923.00 ± 185.06 [a] |
| A | 733.50 ± 194.30 [a] |
| B | 789.17 ± 122.86 [a] |
| C | 807.50 ± 235.36 [a] |

Values are presented as mean ± SD, n = 6

**Height and Weight of Biscuits**

According to the **Table 3**, it showed that the height of the biscuit samples increased after underwent baking process while the weight of the biscuit samples did not have significant difference between before and after baked. The reason why the biscuits spread and expand during baking process because the fat from sugar and butter that content in the dough were melted when there was a difference in temperature. From this reason, seaweed powder did not affect the differences in height of biscuits before and after baked.

**Table 3** Height and weight result before and after baked for different formulation of seaweed biscuits.

| Sample | Height (mm) | | Weight (g) | |
|---|---|---|---|---|
| | Before | After | Before | After |
| Control | 8.09 ± 0.03 | 10.11 ± 0.06 | 6.71 ± 0.10 | 6.79 ± 0.13 |
| A | 8.07 ± 0.03 | 10.07 ± 0.05 | 6.64 ± 0.11 | 6.67 ± 0.10 |
| B | 8.06 ± 0.04 | 10.05 ± 0.05 | 6.62 ± 0.09 | 6.65 ± 0.12 |
| C | 8.07 ± 003 | 10.06 ± 0.08 | 6.65 ± 0.11 | 6.67 ± 0.13 |

Values are presented as mean ± SD, n = 3

**Color Analysis**

The L* value for the seaweed biscuits indicates the level of brightness or darkness, the a* value for greenness or redness and the b* value represent the yellowness or blueness. Based on result in **Table 4**, the L* value for all the samples were nearest to 100 compared to 0 value. It technically shows all the samples have bright in colour based on CIE L* a* b* scale. Furthermore, the value of a* for all the samples showed positive value which brings a redness in colour and b* indicates the yellowness in colour for all samples as it shows positive sign. According to Mamat et al. (2014) the colour of biscuits was produced during baking process due to the Millard reactions between sugars and amino acids as well as due to caramelization process of

sugars. Hence, the changes detected when the amount of seaweed powder raised could be credited to the lower protein contains and the different ratio of amino acid composition of the composite flours. As the percentage of seaweed powder raised, the redness (a*) and yellowness (b*) decreased. As a conclusion, colour of biscuits was affected when the added seaweed powder for the different ratio and the seaweed biscuits in this experiment were redness-yellowness bright in colour.

**Table 4** Colour analysis result for different formulation of seaweed biscuits

| Sample | L* | a* | b* |
|---|---|---|---|
| **Control** | 60.29 ± 1.90 [a] | +7.50 ± 0.30 [a] | +24.58 ± 1.53 [a] |
| **A** | 55.10 ± 1.23 [a, b, c] | +7.01 ± 0.17 [a] | +20.32 ± 0.60 [a, b, c] |
| **B** | 55.11 ± 1.84 [b, c] | +6.11 ± 0.12 [b, d] | +19.95 ± 1.53 [b, c] |
| **C** | 50.05 ± 1.59 [c] | +5.46 ± 0.06 [c, e, f] | +19.93 ± 1.42 [c] |

Values are presented as mean ± SD, n = 3

**Protein Analysis**

Protein is one of the compositions that content in the seaweed. Based on the experimental result, the percentage of the protein that was obtained in the *E. cottonii* seaweed powder was 1.9% from the total dry weight seaweed. According to the Harnedy & FitzGerald (2011) reported that the average amount of protein that contain in the seaweed ranged between 1-47% from total dry weight of seaweed depending on their species. In conclusion, the result from this experimental was acceptable because the percentage of seaweed were within range as reported by Harnedy & FitzGerald (2011).

**Moisture Content**

The range of moisture content in the biscuit samples was between 1.40 to 2.04%, where the higher seaweed powder (20%) amount in the biscuits (sample C) presented the higher moisture content (**Table 5**). This outcome was predicted based on seaweed's well-known water-holding capacity (hydrocolloids). The result obtained in the present study was lesser than the result obtained by Jenifer and Kanjana (2018) in which the moisture content in the 30% seaweed powder is 2.34%.

**Table 5** Moisture content for different formulation of seaweed biscuits.

| Sample | Moisture Content (%) |
|---|---|
| **Control** | 1.46 ± 0.08 [a, c] |
| **A** | 1.40 ± 0.06 [a, b] |
| **B** | 1.78 ± 0.06 [b, c] |
| **C** | 2.04 ± 0.27 [c, d] |

**Sensory Evaluation**

Based on the average total score from hedonic rating scale, most panels give the highest marks for control sample compared to other formulation of seaweed biscuits samples (**Table 6**). However, when compared among the formulation seaweed biscuits samples, the panels give the highest mark for formulation biscuits that contain 10% of seaweed powder compared to other formulation. From the result in **Table 6**, most of the men panels give higher mark for appearance, color and texture of seaweed biscuits compared to female panels, but they give lower mark for aroma, taste and sweetness of seaweed biscuits compared to female panels. In addition, a lot of feedback comments from the panels said they felt uncomfortable when chewing seaweed biscuits that contain 20% of seaweed powder (sample C) but overall feedback comments were satisfactory and most of the panels selected formulation that contain 10% of seaweed powder (sample B) as the accepted formulation compared to others.

**Table 6** Sensory evaluation result for different formulation of seaweed biscuits.

| Sample | Gender | Average Total Score | | | | | |
|---|---|---|---|---|---|---|---|
| | | Appea-rance | Aroma | Taste | Colour | Tex-ture | Sweet-ness |
| **Control** | M | 4.68 | 4.26 | 4.65 | 4.58 | 4.50 | 4.25 |
| | F | 4.52 | 4.56 | 4.68 | 4.55 | 4.48 | 4.36 |
| **A** | M | 4.46 | 4.28 | 4.48 | 4.33 | 4.40 | 4.21 |
| | F | 4.40 | 4.38 | 4.50 | 4.36 | 4.34 | 4.32 |
| **B** | M | 4.41 | 4.22 | 4.32 | 4.28 | 4.16 | 4.18 |
| | F | 4.35 | 4.25 | 4.30 | 4.23 | 4.23 | 4.23 |
| **C** | M | 4.18 | 4.08 | 4.05 | 4.26 | 4.02 | 4.05 |
| | F | 4.11 | 4.14 | 4.08 | 4.21 | 3.96 | 4.13 |

M- Male; F- Female

## CONCLUSION

As conclusions, this research had successfully developed a formulation of biscuit containing seaweed (*Eucheuma cottonii*) powder as a beneficial ingredient in a food production. From the sensory evaluation result, it presented that seaweed powder gave significant effects in appearance, aroma, taste, color, texture, and sweetness of the biscuits. The use of seaweed powder in the formulation also showed great impacts on the physicochemical properties of the final product. Increased the percentage of seaweed powder have increased the level of hardness of biscuits and increased in moisture content in seaweed biscuits. This research has shown that biscuits made from 10% of seaweed powder was judged as most formulation tolerable and acceptable by the panels. In future study, it is suggested for the researcher to focus more on the other impacts of physicochemical properties to improve the formulation of seaweed biscuits. Moreover, researcher also can formulate new seaweed biscuits from other species or can changes the percentage of seaweed in the biscuits to study significant impacts on the biscuits.

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**References**


AOAC. Official Methods of Analysis. 1995. Washington, D.C: Association of Official Analytical Chemists.

Arufe, S., Della Valle, G., Chiron, H., Chenlo, F., Sineiro, J., Moreira, R. 2018. Effect of brown seaweed powder on physical and textural properties of wheat bread. *European Food Research and Technology*. 244(1): 1–10.

Dawczynski, C., Schubert, R. and Jahreis, G. 2007. Amino acids, fatty acids, and dietary fibre in edible seaweed products. *Food Chemistry*. 103(3): 891-899.

Dellarosa, N., L L., Martinsdóttir, E., Jónsdóttir, R. and Sveinsdóttir. K. 2015. Enrichment of convenience seafood with omega-3 and seaweed extracts: Effect on lipid oxidation. *LWT Food Science and Technology*. *62*(1): 746-752.

Guard, A., Rosell, C. M., Benedito de Barber, C. and Galotto, M. J. 2004. Different hydrocolloids as bread improvers and antistaling agents. *Food Hydrocolloids*. 18: 241–247.

Gupta, S., & Abu-Ghannam, N. 2011. Recent developments in the application of seaweeds or seaweed extracts as a means for enhancing the safety and quality attributes of foods. *Innovative Food Science & Emerging Technologies*. 12(4): 600-609.

Harnedy, P. A., Fitzgerald, R. J. 2011. Bioactive proteins, peptides, and amino acids from macroalgae. *Journal of Phycology*. 47(2): 218–232.

Jayasena, V., Nasar-Abbas, S. M. 2011. Effect of lupin flour incorporation on the physical characteristics of dough and biscuits. *Quality Assurance and Safety of Crops and Foods*. 3(3): 140–147.

Jenifer A, & Kanjana K. 2018. Effect of Seaweed Based Biscuit Supplementation on Anthropometric Profile of Malnourished Children Residing at Tuticorin. *PSGCAS Search: A Journal of Science and Technology*. 4(2): 2349–5456.

Khotimchenko, Y.S., Kovalev, V.V., Savchenko, O.V. and Ziganshina, O. A. 2001. Physical– chemical properties, physiological activity, and usage of alginates, the polysaccharides of brown algae. *Russian Journal of Marine Biology*. 27: S53–S64.

Kumar, K. S., Ganesan, K., & Rao, P. V. S. 2008. Antioxidant potential of solvent extracts of Kappaphycus alvarezii (Doty) Doty - An edible seaweed. *Food Chemistry*, 107(1): 289–295.

Leandro, A., Pereira, L., Gonçalves, A. M. M. 2020. Diverse applications of marine macroalgae. *Marine Drugs*, 18(1): 1–15.

Mamat, H., Amin, S. F., Ibrahim, S., Matanjun, P., Abdul Hamid, M. and Rameli, A. S. 2014. The effect of seaweed composite flour on the textural properties of dough and bread. *Journal of Applied Phycology*. 26: 1057–1062.

Phang, S.M., H.Y. Yeong, P.E. Lim, R.M.N. Adibi and K.T. Gan. 2010. Commercial varieties of Kappaphycus and Eucheuma in Malaysia. *Malaysian Journal of Science*. 29: 214–224.

Rosell, C. M., Rojas, J. A. and Benedito de Barber, C. 2001. Influence of hydrocolloids on dough rheology and bread quality. *Food Hydrocolloids.* 15: 75–81.

Syamsuar. 2007. Karakteristik Karagenan Rumput Laut Kappaphycus alvarezii Pada Berbagai Umur Panen, Konsentrasi KOH dan Lama Ekstraksi. www.damandiri.or.id/file/samsuaripbbab1.pdf. [22 April 2020].

Zakaria A, Jais MR, Ishak R. 2018. Analgesic properties of Nigella Sativa and Eucheuma Cottonii extracts. *Journal of Natural Science, Biology and Medicine*. 9(1): 23–26.